Can Low-Power Electromagnetic Radiation Disrupt Hydrogen Bonds in dsDNA?

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Experimental studies abound concerning electromagnetic (EM) effects on the cleavage of DNA. Many of these studies focus on the effect of low-power, low-frequency radiation. These investigations fall into two categories. One is epidemiological, where statistical methods appear to be unable to either rule out, or establish the genotoxic effects of low power, low frequency ambient radiation. The other is laboratory studies of DNA samples subjected to various types of EM radiation. Given the proliferation of technology, the questions raised by these studies cannot be ignored.

The experimental papers referred to above study the cleaving effects of EM radiation, which must involve the breakage of covalent bonds. However, hydrogen bonds couple base-pairs along a dsDNA with energies comparable to normal room temperature. As such, they are more likely to be disrupted by external perturbations than covalent bonds. For this reason, we will focus on coupling EM fields to the phonon modes of dsDNA via bound charges on the strands.

The phonon modes refer to oscillations of the backbone of the DNA molecule. In turn, they couple to the hydrogen bond fluctuations between base-pairs. The bound charges are either native to the dsDNA or are counter-ions adsorbed from the surrounding ionic, aqueous solvent. Adair has provided one of the few theoretical treatments of the coupling of environmental EM radiation on biosystems. He made estimates of the damaging effects of EM radiation on macroscopic, static properties of biological systems and found them to be negligible. His approach is based on the assumption of the linearity of the response of a system to infinitesimal perturbations. Ambient conditions are generally accepted to fall into this category.

However, it is possible that dynamic resonant conditions may amplify the disruptive effects of small perturbations via an instability. The rate of growth of this instability is highly dependent on the power level and frequency of the incident EM radiation. It is greatly limited by dissipation to the ubiquitous aqueous solvent. We have been able to show that EM radiation at frequencies resonant with those of the phonon modes of dsDNA will cause disruption *if* the power level of the EM fields exceeds a critical value, and *if* the coupling to the environment is sufficiently weak.

The two figures show what happens when, first, EM radiation in the microwave region is *not* resonant with the fundamental modes of the dsDNA. The second one shows what happens if the radiation is indeed on resonance, and coupling to the environment is weak.

A paper on this subject has been invited for submission to *Polymer Physics Journal B,* for an issue dedicated, among other topics, to biophysics.

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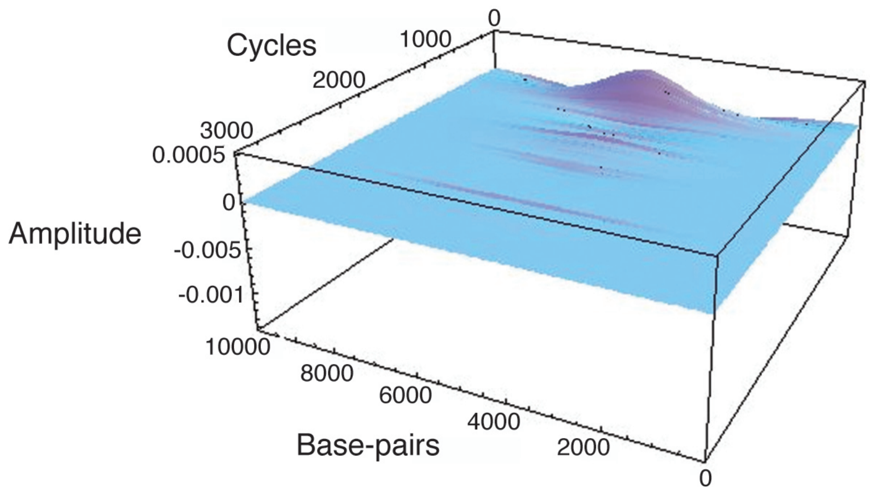

Fig. 1.
What happens when, first, EM radiation in the microwave region is not resonant with the fundamental modes of the dsDNA.

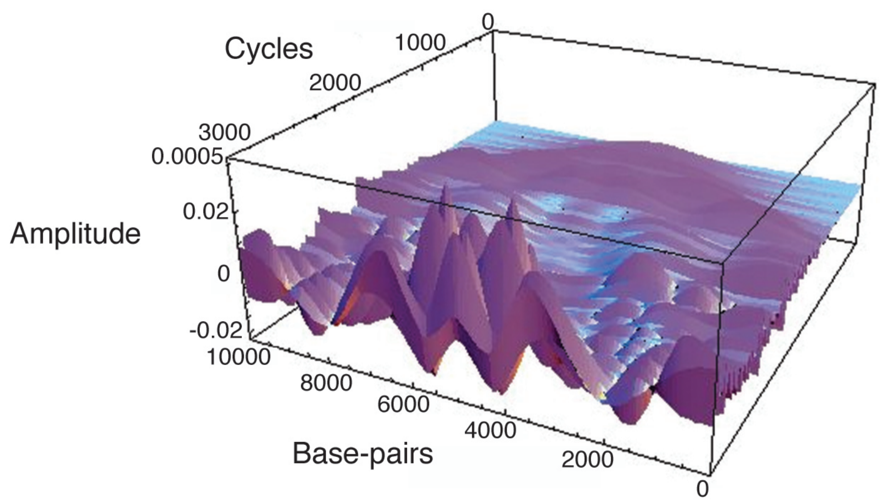

Fig. 2.
What happens if radiation is on resonance, and coupling to the environment is weak.